(12) UK Patent Application (19) GB (11) 2 256 611 (13) A

(43) Date of A publication 16.12.1992

(21) Application No 9112766.2

(22) Date of filing 13.06.1991

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(51) INT CL^5
B29D 7/01

(52) UK CL (Edition K)
B5A AT20P A1R130 A1R214G A1R314C2X
A1R314C3 A1R439H A1R455 A9A

(56) Documents cited
GB 2025302 A GB 1352198 A

(58) Field of search
UK CL (Edition K) B5A AB19 AT16P AT20P AT9P
INT CL^5 B29D

(54) **Manufacture of perforated composite structures**

(57) A curved composite structure suitable for use in noise suppression panelling is fabricated by laying over a curved former (4) a series of rods (5) incorporating a row of pins (6), laying over the rods (5) a perforated, flexible sheet (7) so that the pins (6) protrude through the perforations, and laying over the flexible sheet (7) a prepreg carbon fibre sheet (8) so that this sheet (8) is perforated by the pins. The resulting assembly is then cured. After curing the prepreg sheet is peeled away from the tooling (4, 5, 6, 7) which can be re-used. The method allows easy removal of cured sheets (8) from the tooling without damage to either sheet (8) or pins (6).

Fig.4

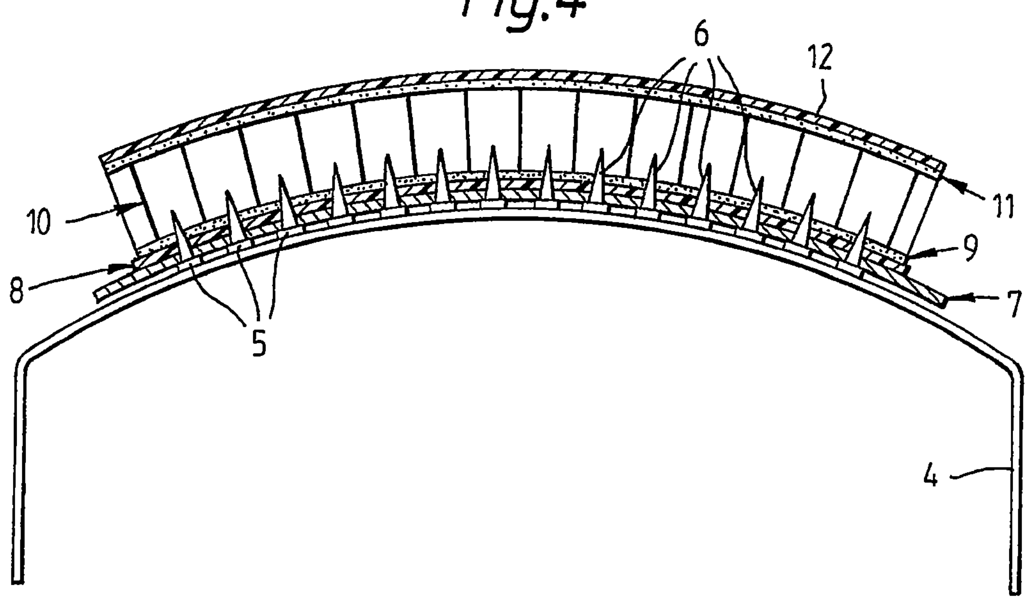

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Fig.1

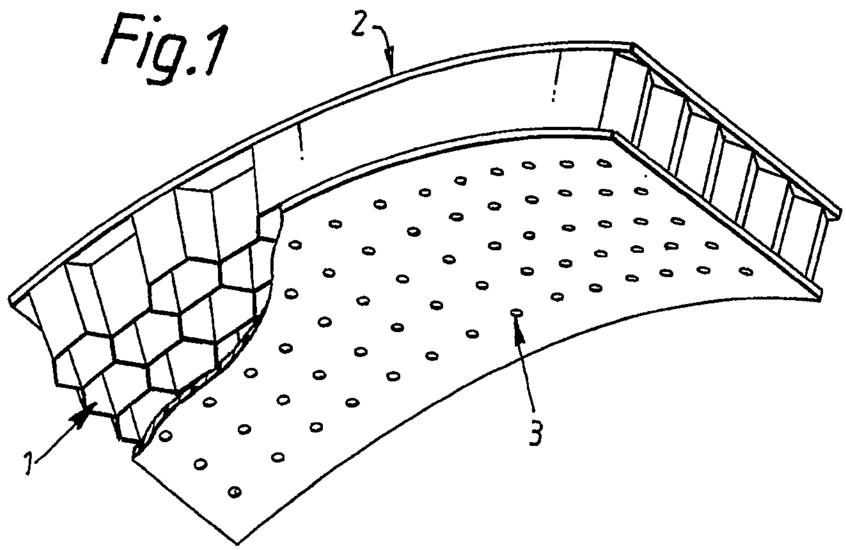


Fig.2

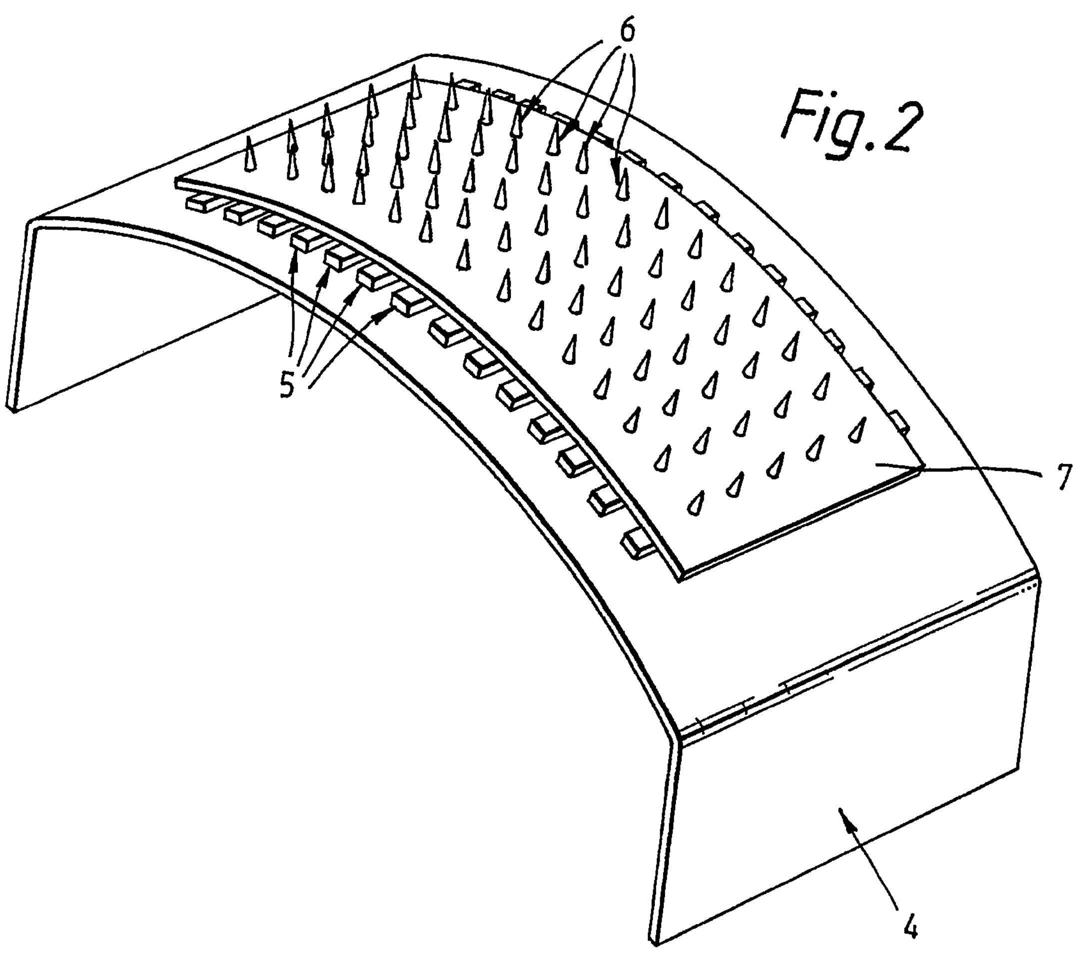


Fig.3

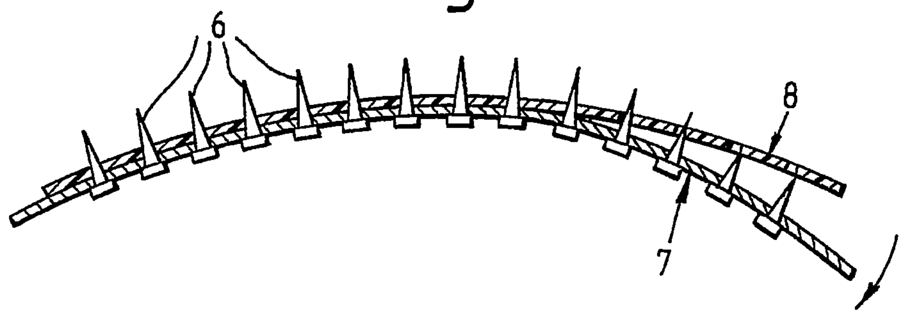
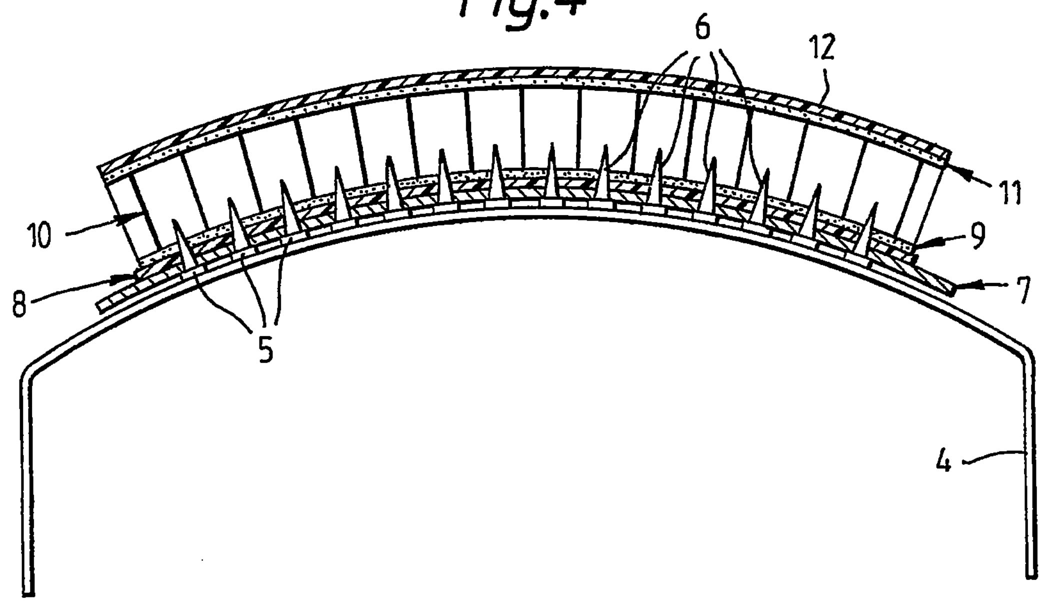


Fig.4



Manufacture of Perforated Composite Structures

This invention relates to a fibre-reinforced composite structure suitable for use in noise suppression panelling.

It is known for turbofan aeroengines to contain noise suppression panelling in regions such as the thrust reverser, inlet cowl and translating cowl assembly. Referring to Fig 1, each panel consists of a honeycomb core 1 having a solid backsheet 2 and a perforated facesheet 3.

One known method of fabrication of the perforated facesheets involves punching or drilling the perforations in sheets of metal or pre-cured carbon fibre composites. When composites are used, however, it has been found that a punching or drilling technique damages the fibres to such an extent that delamination often occurs. In such cases where delamination is severe, the facesheet has to be discarded.

A second known method of fabrication of the perforated facesheets is described in GB1352198 and involves forming the perforations during the curing process. For example, a pre-impregnated fibre sheet is laid over a mould which comprises a base plate fitted with an array of rigid upstanding projections. The projections are allowed to pierce the fibre sheet which is subsequently cured in situ. However, it was found that if the baseplate had a curvature for facilitating the manufacture of a curved facesheet, then removal of the cured facesheet from the baseplate and projections was extremely difficult because the contour of

the facesheet tended to lock the projections in place. Consequently a large number of projections were torn from the baseplate and remained in the facesheet, thus blocking the perforations.

To overcome this disadvantage, a second method was proposed wherein the baseplate and projections were formed (as a unitary structure) of flexible material, in particular, of a plastics material.

The inventors have found, however, that projections made from plastics cannot be made sharp enough to adequately pierce the fibre sheet.

The present invention aims to provide a method of producing either a flat or a curved perforated composite sheet by a process which involves manufacturing the perforations during the curing process and in which said method has none of the aforementioned disadvantages.

A further object of the invention is to provide a method for producing flat or curved sound-absorbing panelling in which said panelling incorporates a perforated composite sheet.

According to a first aspect of the invention, there is provided a method of manufacturing a perforated composite sheet including the steps of:

laying over a former a series of spaced apart rigid rods, each rod incorporating a row of rigid, pointed, upstanding projections;

laying over said series of rods a flexible sheet incorporating perforations so that said projections protrude through the perforations in the flexible sheet;

laying over the flexible sheet a fibre-reinforced resin sheet so that the projections perforate the resin sheet;

subjecting the resulting assembly to heat and pressure so that the resin is cured within the resin sheet; and

peeling off the rods and flexible sheet from the cured resin sheet.

According to a second aspect of the invention, there is provided a method of manufacturing noise suppression panelling including the steps of:

laying over a former a series of spaced-apart rigid rods, each rod incorporating a row of rigid, pointed, upstanding projections;

laying over the series of rods a flexible sheet incorporating perforations so that the projections protrude through the perforations in the flexible sheet;

laying over the flexible sheet a fibre reinforced resin sheet so that the projections perforate the resin sheet;

laying over the resin sheet a sound-absorbing honeycomb structure;

laying over the honeycombed structure a fibre-reinforced resin skin;

subjecting the resulting assembly to heat and pressure so that the resin is cured; and

peeling off the rods and flexible sheet from the cured resin sheet.

Owing to the rigidity of the projections and the flexibility of the flexible sheet, the cured resin sheet can be removed easily, without damage to any of the projections, even when a curved former is employed.

Preferably, the projections are made from metal so that a sharp point can be incorporated therewith.

The rods may be made from metal also e.g. brass, or carbon fibre composite material. They could incorporate more than one row of projections.

The flexible sheet can be made from spring steel or carbon fibre composite for example.

The perforations could be punched or drilled in the flexible sheet.

The former can be made from any suitable stable material and can be flat or curved. Examples of suitable materials will be well known to those familiar with composite tooling.

Some embodiments of the invention will now be described by way of example only with reference to the drawings of which:

Figure 1 is a partly cut-away perspective view of noise suppression panelling;

Figure 2 is a perspective view of apparatus suitable for performing a method of manufacturing a composite structure in accordance with the invention;

Figure 3 is a sectional view of some of the components shown in Figure 2; and

Figure 4 is a sectional view of apparatus suitable for performing a method of manufacturing a noise suppression panel in accordance with the invention.

Referring to Figure 2, the apparatus illustrated comprises a curved former 4 which supports a series of spaced-apart metal bars 5. Each bar 5 is provided with a row of sharply-pointed metal pins 6. Positioned over the bars 5 is a flexible sheet 7 made of spring steel. The flexible sheet 7 is provided with perforations through which the metal pins 6 pass. The flexible sheet 7 follows the contour of the former 4, being held in place by its own weight.

The apparatus is used to manufacture a curved, perforated structure as follows. Firstly, the upper surface of the flexible sheet 7 is coated with a release agent. Next, a pre-impregnated, carbon fibre resin sheet 8 is laid over the flexible sheet 7 and pressed down so that the pins 6 perforate the resin sheet 8 and so that the resin sheet 8 follows the contour of the flexible sheet 7 and former 4. The resulting assembly is placed in a vacuum bag and then in a autoclave until the resin has cured. The cured,

perforated resin sheet 8 and flexible sheet 7 are then peeled apart (see Figure 3), the space between bars 5 allowing the required degree of flexibility. The former 4, pinned bars 5 and flexible sheet 7 can be used again to make further perforated structures.

Manufacture of noise suppression panelling will now be described with reference to Figure 4. The apparatus required for this method is the same as has been described with reference to Figure 2, viz a curved former 4 carrying spaced apart pinned bars 5 and a flexible perforated sheet 7.

In use, a coating of release agent is applied to the upper surface of the flexible sheet 7. Next, a pre-impregnated carbon fibre resin sheet 8 is laid over the flexible sheet 7 so that the pins 6 pierce the resin sheet 8. The upper surface of the resin sheet is coated with a film adhesive 9. Then a sound-absorbing pre-formed honeycomb core structure 10 is placed over the resin sheet 8 and held in place by the pins 6. The pins 6 are made sufficiently short so that they do not protrude beyond the upper surface of the honeycomb structure 10. A further adhesive film 11 is applied to the upper surface of the honeycomb structure 10 and finally a second pre-impregnated carbon fibre resin sheet 12 is pressed onto the adhesive film 11.

Again, the entire assembly is vacuum bagged and placed in an autoclave until the resins have cured.

The resulting curved noise-suppression panel composed of a perforated face sheet, honeycomb core and back sheet is then easily peeled away from the flexible sheet 7 and pins 6.

Using this method it has been found that 100% of the perforations are unblocked by resin or adhesive. This is because the pins 6 remain protruding into the honeycomb core 10 throughout the curing process.

In this method the second resin sheet 12 could initially be uncured or precured.

It has also been found that a higher skin to core bond peel strength is achievable compared with noise suppression panelling fabricated by other methods. This is because when bonding a perforated carbon fibre composite skin to honeycomb core it is usually necessary to reticulate a layer of film adhesive to the top of the cell wall for which the film adhesive must be carrierless. However, when bonding the perforated skin to core whilst positioned on the pins it is possible to use a film adhesive with a carrier which guarantees a more uniform distribution of adhesive thickness.

CLAIMS

1. A method of manufacturing a perforated composite sheet including the steps of:

laying over a former a series of spaced apart rigid rods, each rod incorporating a row of rigid, pointed, upstanding projections;

laying over said series of rods a flexible sheet incorporating perforations so that said projections protrude through the perforations in the flexible sheet;

laying over the flexible sheet a fibre-reinforced resin sheet so that the projections perforate the resin sheet;

subjecting the resulting assembly to heat and pressure so that the resin is cured within the resin sheet; and

peeling off the rods and flexible sheet from the cured resin sheet.

2. A method of manufacturing noise suppression panelling including the steps of:

laying over a former a series of spaced-apart rigid rods, each rod incorporating a row of rigid, pointed, upstanding projections;

laying over the series of rods a flexible sheet incorporating perforations so that the projections protrude through the perforations in the flexible sheet;

laying over the flexible sheet a fibre reinforced resin sheet so that the projections perforate the resin sheet;

laying over the resin sheet a sound-absorbing honeycomb structure;

laying over the honeycombed structure a fibre-reinforced resin skin;

subjecting the resulting assembly to heat and pressure so that the resin is cured; and

peeling off the rods and flexible sheet from the cured resin sheet.

3. A method according to claim 1 or claim 2 in which each rod incorporates more than one row of rigid, pointed, upstanding projections.

4. A method according to any preceding claim in which the rigid, pointed, upstanding projections are made from metal.

5. A method according to any preceding claim in which the rods are made from metal.

6. A method according to any of claims 1 to 4 in which the rods are made from carbon fibre composite material.

7. A method according to any preceding claim in which the flexible sheet is made from spring steel.

8. A method according to any of claims 1 to 6 in which the flexible sheet is made from carbon fibre composite material.

9. A method according to any of claims 2 to 8 in which the fibre-reinforced resin skin is uncured before the assembly is subjected to heat and pressure.

10. A method according to any of claims 2 to 8 in which the fibre-reinforced resin skin is precured before the assembly is subjected to heat and pressure.

11. A method of manufacturing a perforated composite sheet substantially as hereinbefore described with reference to Figs. 2 and 3 of the drawings.

12. A method of manufacturing noise suppression panelling substantially as hereinbefore described with reference to Fig. 4 of the drawings.

Patents Act 1977
Ex...iner's report to the Comptroller under Section 17 (The Search Report)

Application number
9112766.2

Relevant Technical fields

(i) UK Cl (Edition K) B5A (AT9P,AT16P,AT20P,AB19)

(ii) Int Cl (Edition 5) B29D

Search Examiner
DR J RIDDOCH

Databases (see over)

(i) UK Patent Office

(ii)

Date of Search
29 AUGUST 1991

Documents considered relevant following a search in respect of claims ALL

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
Y	GB 2025302 (ROLLS) - cf abstract	1.
Y	GB 1352198 (GEC) - cf Figure 1	1.

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

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E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

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